

# MACHINE DESIGN

## 1976 ANNUAL INDEX

### Volume 48 — January to December

Including 23 regular issues of MACHINE DESIGN plus five special issues—*The Materials Reference Issue, Electric Motors & Controls Reference Issue, Mechanical Drives, Bearings & Seals Reference Issue, Fluid Power Reference Issue, Fastening & Joining Reference Issue.* Only articles and editorial items one-half page or larger are indexed.

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(1) Title.

(2) Author's last name (see AUTHOR INDEX for full name).

Departments in regular issues are denoted by the codes:

N/T ..... News/Trends

DI ..... Design International

Scan ..... Scanning the Field for Ideas

Articles in MACHINE DESIGN Reference Issues are identified by the entry: Chapter (Ref. Issue code).

Reference Issues are coded as follows:

M ..... Materials

EM&C ..... Electric Motors & Controls

MD ..... Mechanical Drives

FP ..... Fluid Power

F&J ..... Fastening & Joining

(3) Date of regular or Reference issue.

(4) Page number.

(5) Number of pages in article or item.

## ELECTRICAL & ELECTRONIC

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Web Loop Control Runs on Reflected Light	Scan	11/11	46	(0.6)
Stepping Switches	Chapter EM&C	4/29	147	(2.2)
Circuit Breakers	Chapter EM&C	4/29	133	(4.2)
Contactors	Chapter EM&C	4/29	146	(1.3)
AC Motor Controls	Chapter EM&C	4/29	102	(3.0)
Soft Braking Capacitor-Start Motors	Gross	9/23	127	(1.0)
Rotary Speed Switches	Chapter EM&C	4/29	131	(1.9)
Reed Switching Devices	Chapter EM&C	4/29	138	(4.0)
Adjustable Switch Hides in Door Hinge	Scan	10/7	50	(0.5)

### 14. Instruments & Controls

Gamma Rays Find the Weapon	N/T	4/22	10	(1.3)
'Credit-Cards' Are Keys in Modern Access Control	Aronson	8/26	20	(6.0)
Position-Sensing Photodiode Measures Angular Position	Scan	10/7	50	(0.5)
How To Linearize A Thermocouple Output	Ritmanich	10/7	136	(2.0)
Using Fiber Optics to 'Wire' Machines	Trumble	1/22	96	(4.0)
Cam Profile Cushions Rotary Solenoid	Scan	7/22	44	(0.5)
Double-Stroke Solenoid Boosts Stepping Switch Torque	Scan	8/12	38	(0.7)
Tradeoffs In Clutch Actuation	Beercheck	9/9	120	(6.0)
Oscilloscopes Learn to Tell Time	Scan	3/25	48	(1.0)
New Muscle For Timing Motors	Lundin	11/11	121	(6.0)

Synchronous Motors	Chapter EM&C	4/29	15	(3.0)
Simple Wire Grid Reduces Graphics To Digital Form	Scan	1/8	38	(0.6)
Logic Analyzer Looks Back In Time	Scan	1/8	40	(1.0)
Digital Revolution in the Test Lab	Wentz	3/25	144	(5.0)
Counters	Chapter EM&C	4/29	205	(2.6)
Taking Accurate Noise-Level Readings	Bentley	6/10	110	(1.0)
What's New in Memories?	Article	7/8	80	(1.0)
Reflected Beta Rays Reveal Coating Thickness	Scan	1/22	37	(0.5)
Oscilloscopes Learn to Tell Time	Scan	3/25	48	(1.0)
Flexible Tuning For Square-Wave Oscillators	Brokaw	4/22	77	(1.2)
Meter-Relays	Chapter EM&C	4/29	151	(1.2)
Current Probe Pinpoints Logic Faults	Scan	9/23	52	(0.6)
Faster Servodrives Through Pulse-Width Modulation	McNaughton	4/22	57	(5.0)
Remote Sensing With Selsyns	VanPatten	10/7	131	(5.0)
New Telescope Called a Bargain	N/T	11/25	18	(0.6)

## 15, 16. Circuit Components, Connectors & Wiring

Continuity Checker Frees Operator's Hands	Scan	2/12	43	(0.5)
When ICs Go Bad	Dicken	2/26	78	(4.0)
ICs That Regulate Voltage	Frostholm	4/8	85	(5.0)
Switching Transistors	Chapter EM&C	4/29	180	(2.6)
Thyristors	Chapter EM&C	4/29	182	(3.3)
Digital Control Modules	Chapter EM&C	4/29	186	(5.8)
Switching Modules	Chapter EM&C	4/29	192	(5.0)
Schottky Diodes Bid for Power Jobs	N/T	5/6	8	(0.5)
Logic Circuit Speeds Up Transistor Testing	Scan	8/26	36	(0.7)
A Mechanical View of Electronic Logic	Khol	9/9	129	(8.0)
Preventing Thyristor Burn-Out	Rice	9/23	114	(4.0)
Photoelectric Systems: Industry's Electronic Eyes	Filichowski	10/7	102	(6.0)
Digital Logic From Sheet Metal To Software	Lutz	11/11	127	(4.0)
Laser Marking	Weiner	11/25	95	(1.7)
Two Tough Production Jobs Prove Easy for Lasers	N/T	2/26	8	(0.8)
High-Density CMOS	Hauer & Koury	12/9	130	(4.0)
Troubleshooting PC Armatures	Uhls	8/12	96	(1.6)
Press-Fit Shaft Lubed Into Laminated Rotor	N/T	10/7	10	(0.7)
Connecting Devices	Chapter EM&C	4/29	255	(4.2)
Avoiding Vibration In Odd-Shaped Printed Circuit Boards	Steinberg	5/20	116	(4.0)
Armature Relays	Chapter EM&C	4/29	141	(4.3)
Heavy-Wire Connector Lowers Cost by Biting Through Insulation	N/T	1/22	10	(0.7)
Barebones Connector Tolerates PC Imperfections	Scan	6/10	48	(0.5)
Pipe Lines for Electricity	Article	3/25	26	(5.0)
Test Switch Opens Ribbon Cable Lines One At a Time	Scan	3/25	54	(0.5)
Wiring	Chapter EM&C	4/29	252	(3.4)
Sea-Bottom Plow Buries Transoceanic Cable	Cobb	8/12	26	(3.0)
Optical Waveguides Carry TV into Homes	N/T	9/9	10	(0.8)
Eliminating Nuisance Tripping in GFI's When the Trade-Offs Favor Aluminum Wiring	Gross	11/11	154	(1.3)
'Dead' Contacts Prolong Rotary Switch Life	Hupp	11/25	94	(1.3)
High-Density CMOS	Scan	9/9	56	(0.5)
Superconducting Motors To Spin Navy Props	Hauer & Koury	12/9	130	(4.0)
Photoelectric Systems: Industry's Electronic Eyes	N/T	8/12	12	(0.7)
	Filichowski	10/7	102	(6.0)

## 17. Miscellaneous Components

Flexible Magnets Shed Hardware Image	Hinderaker	2/12	94	(5.0)
Flying Magnets Coat Complex Parts	Scan	3/11	36	(0.6)
Bucking Magnets Control Keyboard 'Touch'	Scan	6/24	44	(0.5)

# FLUID POWER

## 21, 22, 23. Fluids, Fluid Conditioners, Fluid Conductors

Unsung Heroes of Fluid Power	Article	10/21	146	(2.0)
Why Hydraulic Fluids Aren't Perfect	Leslie	3/11	72	(4.0)
Fluids, Conductors, and Conditioners	Chapter FP	9/30	110	(16.0)
Bearing Temperature Controlled by Evaporating Lubricant	N/T	9/23	6	(0.8)
Lubricants	Chapter MD	6/3	188	(2.7)

Better Motors With Rare-Earth Magnets	Rashidi	7/8	70	(4.0)
Electromagnet Puts Welding Arc in Its Place	Scan	9/9	54	(1.0)
Magnetic 'Cam' Remembers Without Power	Scan	9/9	58	(0.5)
Extruded Ribs Form Warp-Free Aluminum Panels	Scan	4/8	39	(0.7)
Bucking Magnets Control Keyboard 'Touch'	Scan	6/24	44	(0.5)
Parts Encapsulated in Single-Liquid Process	N/T	6/10	6	(0.5)
Using Fiber Optics to 'Wire' Machines	Trumble	1/22	96	(4.0)
'Get the Sun Out of the Office'	N/T	7/22	10	(0.8)
A New Breed of Miniature Lamps	N/T	7/22	72	(6.0)
'Ma Bell' Tests Lasers 'Talking' into Fibers	N/T	8/12	6	(1.0)
Fiber Optics Monitor Oil-Tank Levels	Scan	10/21	44	(0.6)
Selecting Fiber-Optic Cables	Article	12/9	156	(1.0)
Saturated Vapor Solders Complex Parts	Scan	3/25	52	(0.6)
Automatic Braking of Three-Phase Motors	Gross	1/8	92	(1.2)
Dynamic Braking: Making a Motor Stop Itself	Ander	5/6	86	(5.0)
Eddy-Current Braking Improves Step Motor Response	Amir	5/20	124	(1.5)
Clutches and Brakes	Chapter MD	6/3	27	(6.7)
Magnetic Switch Stops Speeding Motors	Scan	8/26	38	(0.7)
Ferroresonance Improves Motor Braking	Gross	8/26	91	(1.8)
Saving Energy With Electromagnetic Clutches and Brakes	Wilson	11/11	136	(6.0)
Electronics Paces 1977 Engine Redesign	Wise	10/7	20	(6.0)

## 19. Systems & Assemblies

Computer Programs For Analyzing Rotor Systems	Rieger	1/22	89	(7.0)
New RPV Impressive on First Flights	N/T	2/12	4	(1.0)
Flexible Tuning For Square-Wave Oscillators	Brokaw	4/22	77	(1.2)
Timers	Chapter EM&C	4/29	200	(5.0)
Integrated Circuit Gives Green Light to Minibikes	Scan	6/10	42	(1.0)
Electronic Tape Measure Monitors Machine Tool Motion	Scan	6/10	46	(0.7)
Safer 'Software' For Programmable Controllers	Rodriguez & Harrison	8/12	76	(5.0)
'Credit-Cards' Are Keys in Modern Access Control	Aronson	8/26	20	(6.0)
Machine Tools Embrace New Technology	Article	8/26	70	(8.0)
Electromagnet Puts Welding Arc in Its Place	Scan	9/9	54	(1.0)
Magnetic 'Cam' Remembers Without Power	Scan	9/9	58	(0.5)
NC Inspires New Machine Configurations	Khol	9/23	32	(2.5)
Electric Controls For Hydrostatic Drives	Joyal	10/7	114	(4.0)
Upgrading Older Machine Tools	Article	10/21	136	(1.0)
Pinpoint Control Refines Rotary Blow Molding	Scan	11/25	44	(1.0)
An Introduction to Microcomputer Software	Leonard	11/25	70	(7.0)
Pencil Marks Program Events Controller	Scan	12/9	48	(0.6)
Graphic Input Terminal Uses Wireless Stylus	Scan	4/22	36	(0.7)
What's Coming in Big Computers	Comella	4/22	66	(6.0)
The 'Hidden' Costs in Designing With Microcomputers	Barnick	6/24	80	(4.0)
Test Equipment for Microcomputers	Raphael & Hou	8/26	78	(4.0)
Computer Replaces Camshaft in Experimental Engine	Scan	12/9	42	(1.0)
Anatomy of a Microcomputer	Schwartz & Kute	3/11	60	(7.0)
ELECTRIC MOTORS AND CONTROLS 1976	Chapter EM&C	4/29	2	(6.0)
Sequence Controllers	Chapter EM&C	4/29	207	(1.2)
Electronic Controllers	Chapter EM&C	4/29	208	(1.2)
Microcomputer Terminology	Chapter EM&C	4/29	210	(2.0)
Power-Control Modules	Chapter EM&C	4/29	212	(3.2)
How To Compare Microprocessors	Bonzon & Schneider	9/23	104	(4.0)
Microprocessor Synchronizes Complicated Machine Functions	Scan	11/25	38	(0.6)
An Introduction to Microcomputer Software	Leonard	11/25	70	(7.0)
DC Motor Controls	Chapter EM&C	4/29	105	(1.3)
Using Fiber Optics to 'Wire' Machines	Trumble	1/22	96	(4.0)



Superfrozen Permafrost Anchors Alaskan Pipeline	N/T	1/22	4	(0.5)
Spiral Tubing Soaks Up Sun's Rays	Scan	1/22	36	(0.7)
The Heat Pipe: Hot New Way to Save Energy	Aronson	3/11	52	(5.0)
Rigid Foam Makes Low-Cost Heat Collector	Scan	4/8	36	(0.5)
The Heat Pipe: Hot New Way to Save Energy	Aronson	3/11	52	(5.0)
The Vortex Tube: Cooling With Compressed Air	Aronson	9/12	140	(4.0)
Fuel Spinner Produces Hot Flame	N/T	1/8	36	(0.5)
Rotating Electrode Doesn't Contaminate Alloy Melts	Scan	1/22	37	(0.5)
Radiation-Cured Coatings	Lindstrom, Arons & Rafferty	5/6	96	(6.0)
Double-Plunger Dispenser Cleans Up Epoxy Bonding	Scan	4/8	36	(0.5)
Crisscross Hole Pattern Mixes and Remixes Plastic	Scan	5/6	45	(0.5)
Leak-Free Hydraulics	Lansky	7/8	60	(5.0)
Plastic Fittings Fight Corrosion And High Cost	Davies	4/8	69	(3.0)
Couplings	Chapter MD	6/3	33	(3.3)
Simplified Joint Design For Formed-In-Place Gaskets	Kruszona	10/21	109	(5.0)
Muffling Hydraulic Systems	Skaistis & Becker	10/21	124	(5.0)
Double-Plunger Dispenser Cleans Up Epoxy Bonding	Scan	4/8	36	(0.5)
Squeeze Bottle Dispenses Foam, Wet Spray, or Dry Mist	N/T	7/8	12	(0.8)
Centrifugal Force Blends No-Lump Mixtures	Scan	12/9	46	(0.6)

## 24. Linear Devices

Slotted Cylinder Cuts Mounting Space in Half	Scan	2/26	42	(0.5)
Cams That Cushion Cylinders	Shasha	4/22	76	(1.8)
How To Get 600 hp Out of a 3½-in. Cylinder	Scan	6/10	44	(0.7)
Curing Slider Hang-Ups	Kleven	6/24	105	(5.0)
"Springs" That Don't Fatigue	Zahid	2/12	110	(3.0)
Hydraulic 'Spring' Steadies Seagoing Derricks	Scan	8/12	44	(1.0)
"Springs" That Don't Fatigue	Zahid	2/12	110	(3.0)
Tradeoffs In Clutch Actuation	Beercheck	9/9	120	(6.0)
Power Actuators and Shock Absorbers	Chapter FP	9/30	164	(12.0)
Controlling Valves From a Distance	Breeden & Royston	12/9	144	(5.0)
Composite Speedbrake Going on F-15e	N/T	3/11	12	(0.5)

## 25. Rotary Devices

Holey Plate Squeezes Noisy Pumps	Scan	6/24	44	(0.5)
Coming: Quieter Pumps	Robbins & Logan	9/9	116	(4.0)

# MECHANICAL

## 28. Instruments & Controls

Promising Newcomers for Tough Flow Measurements	Kivenson	1/8	78	(4.0)
Floats on Pulleys Keep Track of Tank Levels	Scan	2/12	46	(0.6)
Hanging Chain Senses Bin Levels	Scan	5/20	52	(1.0)
Fiber Optics Monitor Oil-Tank Levels	Scan	10/21	44	(0.6)
Intake Air Regulates Fuel-Injection System	Scan	11/11	42	(1.0)
Fluid Logic and Controls Chapter	Chapter FP	9/30	282	(5.0)
Digital Logic From Sheet Metal To Software	Lutz	11/11	127	(4.0)
Superfrozen Permafrost Anchors Alaskan Pipeline	N/T	1/22	4	(0.5)
Inserts That Stay Put	Strasser	11/11	142	(4.0)

## 29. Systems & Assemblies

Hydraulic Systems With Precision Reflexes	Dransfield & Labrody	5/20	106	(4.0)
Another Way To Look At Hydraulic Systems	Henke	7/22	90	(5.0)
Hydraulic Systems That Conserve Energy	Henke	8/12	81	(5.0)
Electric Controls For Hydrostatic Drives	Joyal	10/7	114	(4.0)

Avoiding The Perils of Cavitation	Timmerman	9/23	99	(5.0)
Power Input and Storage Devices	Chapter FP	9/30	8	(12.0)
Fluid Handling Components	Chapter FP	9/30	260	(8.0)
Cam-Driven Valves Help High-Altitude Pump	Scan	11/25	40	(0.7)
Selecting High-Torque Hydraulic Motors	Henke	1/8	70	(5.0)
Compressor Lobes Squeeze Air Without Seals	Scan	2/12	42	(1.0)
Teeter-Totter Valve Takes Its Cue From Cams	Scan	7/22	40	(1.0)
Power Actuators and Shock Absorbers	Chapter FP	9/30	164	(12.0)
Controlling Valves From a Distance	Breeden & Royston	12/9	144	(5.0)

## 26. Seals

Fluid Seals and Packings	Chapter FP	9/30	212	(6.0)
Face Seals	Chapter MD	6/3	252	(3.8)
Radial Lip Seals	Chapter MD	6/3	255	(2.9)
Clearance Seals	Chapter MD	6/3	261	(1.7)
Designing the Leakproof Gasket	Swick	1/22	100	(4.0)
Nonmetallic Gaskets	Chapter MD	6/3	271	(2.2)
Metallic Gaskets	Chapter MD	6/3	276	(2.7)
Simplified Joint Design For Formed-In-Place Gaskets	Kruszona	10/21	109	(5.0)
Exclusion Devices	Chapter MD	6/3	258	(2.3)
Split Ring Seals	Chapter MD	6/3	262	(1.0)
Compression Packings	Chapter MD	6/3	263	(1.7)
Lip Packings	Chapter MD	6/3	266	(1.7)
Squeeze Packings	Chapter MD	6/3	268	(2.0)
Keeping Seals Tight	Barbarin	8/26	92	(1.2)
Two-Ring Seal Won't Extrude	Scan	10/7	52	(0.5)
Urethane Foam from a Pressurized Can	N/T	10/21	28	(0.8)
Diaphragm Seals	Chapter MD	6/3	271	(0.8)

## 27. Valves

Fluid Handling Components	Chapter FP	9/30	260	(8.0)
Power Modulation and Control Devices	Chapter FP	9/30	46	(13.0)
Slide-Action Valves in Fluid Lines	Scan	12/9	45	(0.5)
Buckled Plates Control Fluid Flow	Scan	5/6	42	(0.7)
Spinning Ball Senses Fuel Flow Rate	Scan	10/7	49	(1.0)
Floating Flowmeter Needs No Bearings	Scan	11/11	48	(0.5)
Designing Axial-Motion Valves	Brown	11/25	92	(2.0)
"Springs" That Don't Fatigue	Zahid	2/12	110	(3.0)
Minicals Find Supersonic Boundary-Layer Thickness	Logan & Mekuria	2/12	118	(1.3)
Do-It-Yourself Hovercraft	N/T	3/11	25	(1.0)
Double Valve Combines Series & Parallel Flow	Scan	10/21	38	(1.0)
Intake Air Regulates Fuel Injection System	Scan	11/11	42	(1.0)
The Vortex Tube: Cooling With Compressed Air	Aronson	9/12	140	(4.0)

## Vacuum Lowers Cost of Investment

Castings	Dreger	4/22	62	(4.0)
Optimizing Pneumatic Conveyors	Stupak	5/20	125	(2.5)
Lubricating Systems	Chapter MD	6/3	196	(3.0)
Felt Radial Seals	Chapter MD	6/3	270	(1.0)
How to Choose An Automatic Lube System	Beercheck	6/24	90	(5.0)
Lubricating Disc Impresses a Truckers Changes and Challenges in Bearing Design	N/T	7/8	6	(0.7)
Optical Computer Takes the 'Ouch' Out of Hypodermics	Tallian	11/11	18	(6.0)
	Scan	5/6	38	(1.0)

## 31. Power Sources

Energy Shortage Forcing 'Manufacturing Revolution'	N/T	1/22	8	(0.8)
EPA Wants Tougher Evaporative Standard for Autos	N/T	2/26	12	(0.5)
Ford Shows Latest Stirling Engines	N/T	5/20	4	(2.0)
Biggest Rotary Developed for Industrial Use	Chapter MD	6/3	43	(2.0)
Electronics Paces 1977 Engine Redesign	N/T	6/24	10	(1.3)
Dual-Displacement Engine Boosts Fuel Economy	Wise	10/7	20	(6.0)
Variable Piston Stroke Boosts Engine MPG	N/T	10/21	10	(2.0)
Coming Soon—The VW Diesel	N/T	11/11	30	(2.0)
Two Major Fusion Advances Reported	Aronson	11/25	20	(3.0)
	N/T	5/6	12	(0.5)

Nuclear Scoreboard: 60 Plants Up, 178 Coming	N/T	9/23	36	(6.5)
Biggest Rotary Developed for Industrial Use	N/T	6/24	10	(1.3)
Engineering Students 'Modernize' The Coal Industry	Aronson	7/8	18	(4.0)
Auto Fuel: 2 Parts Water, 1 Part Liquid Hydrocarbon	N/T	10/7	8	(0.7)
Electrolysis Separates Oil from Waste Water	N/T	11/11	12	(0.7)
Spiral Tubing Soaks Up Sun's Rays	Scan	1/22	36	(0.7)
Moving Focal Point Lightens Tracking System's Load	Scan	2/12	43	(0.5)
Rigid Foam Makes Low-Cost Heat Collector	Scan	4/8	36	(0.5)
Something In The Wind? ERDA Thinks So	Black	5/20	18	(7.0)
Advanced Turbine Designs Boost Wind-Power Potential	Black	6/10	26	(6.0)
Navy Builds an Energy-Test House	N/T	7/22	8	(0.8)
Largest Windmill to Produce 1.5 MW	N/T	9/9	6	(0.7)
Fixed Mirrors To Power City	N/T	10/7	6	(0.6)
Install Solar Panels On Your Roof?	N/T	10/7	6	(0.6)
Wind Energy + Water + Air = Food	N/T	11/25	4	(1.0)
Geothermal Research Encouraging	N/T	12/9	6	(0.5)
How Solar Energy Is Used	N/T	12/9	12	(0.5)
Pedal Power: Muscling In On The Energy Crisis	Black	9/23	30	(2.0)

## 32, 33, 34. Drives, Transmissions, Drive Components

Mechanical Drives: More From Less	Article	10/21	138	(2.0)
Chains	Chapter MD	6/3	20	(1.9)
Wind-Up Tensioner Keeps Chain Drive in the Running	Scan	7/22	46	(0.6)
Floating Shuttle Simplifies High-Speed Tape Drive	Scan	8/12	42	(0.5)
"Sensor" Gears Preserve Constant Velocity Ratio For Angled Shafts	Scan	1/8	34	(1.0)
Sizing Planetary Reduction Gears	Carter	6/10	108	(1.4)
'Focused' Piston Tunes Out Vibrator Dead Spots	Scan	8/26	42	(0.5)
Adjustable-Speed Drives	Chapter MD	6/3	8	(5.4)
Mechanical Drives: More From Less	Article	10/21	138	(2.0)
Chains	Chapter MD	6/3	20	(1.9)
Backpedaling Transmission Shifts Bicycle Gears	Scan	7/22	42	(0.7)
Variable-Speed Belt Drives	Morris	8/12	88	(5.0)
Power Flow in a Differential	Shen	4/8	77	(3.0)
Eccentric Transmission Shifts Speeds Without Gears	Scan	2/26	38	(1.0)
Mechanical Drives: More From Less	Article	10/21	138	(2.0)
Epoxy Plug Forms Tenacious Cable Terminal	Scan	9/9	56	(0.5)
Rigging Trims Wheels on All-Terrain Vehicle	Scan	11/25	42	(0.5)
Belt Drives	Chapter MD	6/3	22	(4.5)
Power Flow in a Differential	Shen	4/8	77	(3.0)
Gears and Gear Drives	Chapter MD	6/3	13	(7.0)
Thermoplastic Gears—Part 1: Material Properties	Shanley & Lamond	12/9	125	(5.0)
Drive Sprocket Molded from Super-Tough Nylon	N/T	8/26	8	(0.5)
Rigging Trims Wheels on All-Terrain Vehicle	Scan	11/25	42	(0.5)

## 35. Rotational Components

Taking a Close Look at Bearing Wear	Dalal	1/8	82	(4.0)
Power Screw or Ball Screw?	Lochmoeller	3/11	76	(4.0)

Predicting Bearing Temperature	Witte	5/20	110	(6.0)
Bearings	Chapter MD	6/3	150	(4.0)
Rolling-Element Bearings	Chapter MD	6/3	165	(10.8)
Premounted Bearings	Chapter MD	6/3	176	(1.7)
Easy Way To Find Bearing Curvature	Archibald	9/23	126	(1.7)
Large-Diameter Bearings	Pritts & Myers	10/21	129	(7.0)
Changes and Challenges in Bearing Design	Tallian	11/11	18	(6.0)
Hub Unit Bearings Toughen Off-Road Racer	N/T	11/25	6	(0.8)
Stadium Floats Into Position For Any Sport	N/T	1/8	10	(0.6)
Choosing a Rod End Bearing	Keller	2/26	90	(4.0)
Stabilizing Herringbone-Grooved Journal Bearings	Fleming & Hamrock	2/26	101	(2.0)
Metals for Nonlubricated Wear	Schumacher	3/11	57	(3.0)
Woven Fabric Shapes Exotic Bearings	Scan	5/20	46	(1.0)
Bearings	Chapter MD	6/3	150	(4.0)
Plain Bearings	Chapter MD	6/3	154	(6.2)
Sliding-Bearing Materials	Chapter MD	6/3	160	(5.3)
Swinging Pad Bearing Floats on Water	Scan	7/8	32	(1.0)
Friction Loss in Small Journal Bearings	Thoen	8/26	82	(4.0)
Couplings	Chapter MD	6/3	33	(3.3)
Universal Joints	Chapter MD	6/3	37	(2.3)
Auxiliary Components	Chapter MD	6/3	39	(4.3)
Clutches and Brakes	Chapter MD	6/3	27	(6.7)
Rating the Load Capacity of Involute Splines	Drago	2/12	104	(6.0)
Wrenching Systems For Easy Assembly	McCormick	7/22	95	(1.4)
Toggles Keep Tabs on Torque	Scan	11/11	44	(0.6)
Computer Replaces Camshaft in Experimental Engine	Scan	12/9	42	(1.0)
Eccentric Transmission Shifts Speeds Without Gears	Scan	2/26	38	(1.0)
Clutches and Brakes	Chapter MD	6/3	27	(6.7)
Rubber Hose Makes Simple Clutch	Scan	6/10	48	(0.5)
How To Do More With Wrapped-Spring Clutches	Lowery & Mehrbrodt	7/22	78	(6.0)
New Bus Stresses Comfort and Convenience	NT	7/8	4	(0.7)
Specialty Bearings	Chapter MD	6/3	178	(10.1)
New Materials for Flywheels	Article	9/9	140	(0.5)

## 36, 37. Mechanisms, Controls

Dynamic Distortion in Cam Systems	Tesar & Matthew	3/25	186	(6.0)
Cams That Cushion Cylinders	Shasha	4/22	76	(1.8)
3-D Linkages Simplify Complex Mechanisms	Rice	6/10	100	(5.0)
Four-Bars For Limited Space	Rao	6/24	110	(0.8)
Positioning Fixture Saves Setup Time	Scan	9/23	50	(0.7)
Defining 'Precision' In A Control System	Sethi	4/8	80	(5.0)
Gentle Squeeze Puts the Brakes on Speeding Parts	Scan	7/8	36	(0.6)
3-D Linkages Simplify Complex Mechanisms	Rice	6/10	100	(5.0)
Power Screw or Ball Screw?	Lochmoeller	3/11	76	(4.0)
Tradeoffs In Clutch Actuation	Beercheck	9/9	120	(6.0)
Two-Speed Control Positions Machine Tools	Scan	9/23	54	(0.7)
Frequency Control Fine Tunes Feeder Performance	Scan	7/8	38	(0.6)
Tool Shop Open to Ocean Depths	N/T	11/25	12	(0.7)
Centrifugal Force Blends No-Lump Mixtures	Scan	12/9	46	(0.6)
C-Clamp Forms Simple Pressure Transducer	Scan	9/23	49	(0.7)
Lower Cost Protection For RR Crossings	Article	10/7	30	(2.0)

## 39. Systems

Changes and Challenges in Bearing Design	Tallian	11/11	18	(6.0)
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# ASSEMBLY COMPONENTS

## 41, 42, 43. Fasteners, Springs & Isolation Devices, Misc.

New Coater and New Coatings Developed for Fasteners	N/T	3/11	6	(0.5)
How Special Fasteners Improve a Product	Trilling	5/6	102	(4.0)
Fasteners and Adhesives '76	Chapter FJ	11/18	2	(3.0)
Plastic Fasteners	Chapter FJ	11/18	119	(2.3)
Breakaway Insert Speeds Installation	Scan	10/7	54	(0.7)
Inserts That Stay Put	Strasser	11/11	142	(4.0)
Nuts and Inserts	Chapter FJ	11/18	13	(7.3)
Tolerant Threads Mate With Standard Fasteners	Scan	12/9	44	(0.5)
Non-Threaded Fasteners	Chapter FJ	11/18	80	(1.6)
Latch and Trip Mechanisms	Ram	2/26	99	(2.0)
Quick-Operating Fasteners	Chapter FJ	11/18	126	(2.6)
Which Standards for Metric Retaining Rings?	Millheiser	2/26	86	(4.0)

Retaining Rings	Chapter FJ	11/18	81	(3.4)
Non-Threaded Fasteners	Chapter FJ	11/18	76	(4.0)
Optimum Bolt Head Design	Article	6/10	109	(0.6)
Safer Tightening For Bolted Joints	Rice	6/24	100	(5.0)
Wrenching Systems For Easy Assembly	McCormick	7/22	95	(1.4)
Repositioned Threads Give Fastener Wide Tolerance Range	Scan	10/7	52	(0.5)
Bolts, Screws, and Studs	Chapter	11/18	5	(7.7)
Washers	Chapter FJ	11/18	90	(1.0)
Gage Ring Indicates Fastener Tension At a Touch	Scan	1/22	40	(0.5)
Clamping Fixture Squares Wood Frames	Scan	4/22	34	(0.7)
Tapered Tapes Make Tough Joints	Scan	5/6	40	(0.7)
Pipe Clamp Plugs Leaky Joints Without Shutdown	Scan	9/9	58	(0.5)
Formed Metal Fasteners	Chapter FJ	11/18	118	(1.7)
Fatigue Failure In Springs	Kuraz	5/6	106	(5.0)
Stamped Spring Steel Fasteners	Chapter FJ	11/18	122	(2.5)
"Springs" That Don't Fatigue	Zahid	2/12	110	(3.0)
Infinite Life Torsion Springs	Keck	2/12	119	(1.5)
Minimum Length Springs	Agrawal	5/20	128	(1.0)

Check The Body Radius For High Stress	Article	6/24	110	(1.2)
How To Do More With Wrapped-Spring Clutches	Lowery & Mehrbrodt	7/22	78	(6.0)
Sizing Helical Springs	Ganapathy	9/9	139	(1.5)
Set and Relaxation in Flat Springs	Ullman	11/11	131	(5.0)
Snap-In Stud Soaks Up Shock, Pushes Panels	Scan	11/25	42	(0.5)
Cylinder Spear Softens Shock Step by Step	Scan	1/22	40	(0.5)
Snap-In Stud Soaks Up Shock, Pushes Panels	Scan	11/25	42	(0.5)
'Credit-Cards' Are Keys in Modern Access Control	Aronson	8/26	20	(6.0)
Laser Marking	Weiner	11/25	95	(1.7)
Trim Machining Costs By Designing With Shims	Weiss	7/22	69	(3.0)
Six-Wheeler May See Grand-Prix Action	Article	2/12	20	(1.5)
Gimbal Ring Design	Blake	4/8	92	(1.6)
Curing Slider Hang-Ups	Kleven	6/24	105	(5.0)
Adjustable Switch Hides in Door Hinge	Scan	10/7	50	(0.5)

## MATERIALS

### 51, 52. Ferrous, Nonferrous Metals

MATERIALS 1976: The Materials Supply	Chapter M	3/4	2	(6.0)
Picture	Ebert	8/12	18	(5.0)
Materials in Sports	Article	10/21	142	(2.0)
Materials: Spotlight Falls on Properties	Chapter FJ	11/18	20	(3.2)
Introduction to Ferrous Metallurgy	Chapter M	3/4	8	(1.8)
Formability of Steel Sheets Improved by Temperature Control	N/T	11/11	32	(0.5)
Cast Iron	Chapter M	3/4	9	(2.5)
Carbon Steel	Chapter M	3/4	12	(2.0)
Alloy Steel	Chapter M	3/4	16	(2.8)
Stainless Steel	Chapter M	3/4	24	(1.7)
Metals for Nonlubricated Wear	Schumacher	3/11	57	(3.0)
Tool Steel	Chapter M	3/4	21	(1.8)
Steels for Strength	Chapter M	3/4	26	(1.5)
HSLA Steel	Chapter M	3/4	28	(1.0)
Iron-Based Superalloys	Chapter M	3/4	29	(0.8)
HSLA I-Beams Welded Together	N/T	7/22	12	(0.8)
HSLA Steels Face New Competition	N/T	9/23	18	(0.8)
Introduction to Nonferrous Metallurgy	Chapter M	3/4	50	(2.1)
Aluminum	Chapter M	3/4	53	(2.9)
Coming Soon: Low-Cost Production Aluminum	Dreger	3/11	81	(1.1)
Plating	N/T	3/25	12	(0.7)
Small Crew Handles Huge Aluminum Sailing Vessel	Scan	4/8	39	(0.7)
Extruded Ribs Form Warp-Free Aluminum Panels	N/T	8/12	8	(0.8)
7 x Boost in Wear Resistance for Aluminum	N/T	11/25	18	(0.6)
P/M Parts	Hupp	11/25	94	(1.3)
New Telescope Called a Bargain	Chapter M	3/4	56	(1.1)
When The Trade-Offs Favor Aluminum Wiring	Chapter M	3/4	57	(2.0)
Beryllium	Chapter M	3/4	60	(0.7)
Copper	Chapter M	3/4	63	(2.0)
Magnesium	Chapter M	3/4	70	(1.0)
Nickel	Chapter M	3/4	73	(1.4)
Titanium	Chapter M	3/4	68	(0.8)
Zinc	Chapter M	3/4	216	(0.6)
Refractory Metals	Chapter M	3/4	66	(1.1)
Refractory Hard Metals	Chapter M	3/4	68	(0.7)
Precious Metals	Chapter M	3/4	68	(0.7)
Tin	Chapter M	3/4	68	(0.7)

### 53, 54. Plastics, Rubber & Elastomer

Introduction to Polymer Chemistry	Chapter M	3/4	120	(4.0)
Designing With Plastics	Chapter M	3/4	124	(3.0)
You Can Predict Creep in Plastic Parts	Rondeau	3/11	67	(5.0)
Plastic Fittings Fight Corrosion And High Cost	Davies	4/8	69	(3.0)
Plastic Fasteners	Chapter FJ	11/18	119	(2.3)
Plastic Joining	Chapter FJ	11/18	163	(3.0)
New Nylon Resin: A Toughness Previously Unknown to Engineering Plastics	N/T	1/22	6	(0.7)
Stronger Thermoplastic Elastomers	Theberge & Arkles	2/12	113	(4.0)
ABS	Chapter M	3/4	127	(1.0)
Acetal	Chapter M	3/4	128	(1.3)
Acrylic	Chapter M	3/4	129	(1.3)
Celluloses	Chapter M	3/4	133	(1.1)
Fluoroplastics	Chapter M	3/4	136	(2.4)
Nylon	Chapter M	3/4	138	(1.2)
Phenylene Oxide	Chapter M	3/4	141	(0.9)
Polycarbonate	Chapter M	3/4	142	(1.0)
Polyimide	Chapter M	3/4	145	(1.0)
Polyolefins	Chapter M	3/4	146	(2.8)
Polyphenylene Sulfide	Chapter M	3/4	151	(0.7)
Polysulfone	Chapter M	3/4	151	(0.7)
Polystyrene	Chapter M	3/4	152	(0.9)
Polyvinyl Chloride	Chapter M	3/4	154	(1.0)
Reinforced Thermoplastics	Chapter M	3/4	156	(1.3)
Thermoplastic Elastomers	Chapter M	3/4	199	(1.2)
Kevlar Looks Good as Parachute Material	N/T	4/8	12	(0.6)
The Latest in Structural Plastic Panels	Dreger	6/10	105	(3.0)
Plastic Converts Van into Armored Truck	N/T	6/24	6	(0.8)
Drive Sprocket Molded from Super-Tough Nylon	N/T	8/26	8	(0.5)

### 44. Mechanical Measurement Equipment

Machine Tool Checks Up on Itself	Scan	4/22	33	(1.0)
Double Vision Takes the Boredom Out of Bore Measurements	Scan	3/25	54	(0.5)
No Touch Alignment System Works Without Gages	Scan	4/8	35	(1.0)
Machine Tool Checks Up on Itself	Scan	4/22	33	(1.0)
Strain Gages Zero-In Big Gun Quickly	Zimmerman	5/20	36	(2.0)
Floating Rollers Weigh Fabric on the Fly	Scan	6/24	42	(1.0)
Bending-Beam Scale Gives Honest Weight	Scan	7/22	44	(0.5)
Weighing System Puts Load on a Pedestal	Scan	8/12	42	(0.5)
Simple Indicator Measures Surface Angle	Scan	11/11	48	(0.5)
Predicting Bearing Temperature	Witte	5/20	110	(6.0)

### Thermoplastic Gears—Part 1: Material Properties

Stampable Plastics Challenge Sheet Steel	Shanley & Lamond	12/9	125	(5.0)
Alkyd	Dreger	12/9	134	(6.0)
Allylic	Chapter M	3/4	130	(0.8)
Amino	Chapter M	3/4	131	(1.2)
Epoxy	Chapter M	3/4	132	(1.0)
Phenolic	Chapter M	3/4	135	(1.0)
Polyester	Chapter M	3/4	139	(1.2)
Polyimide	Chapter M	3/4	143	(1.7)
Silicone	Chapter M	3/4	145	(1.0)
Reinforced Thermosets	Chapter M	3/4	155	(1.0)
Thermoset Elastomers	Chapter M	3/4	159	(1.5)
Plastic Parts Produced by Spin-Casting	Chapter M	3/4	196	(3.8)
Reinforced Plastic Parts from Low-Pressure Molds	N/T	9/9	10	(0.6)
Reinforced Thermoplastics	Dreger	1/8	75	(3.0)
High-Temperature Plastics	Chapter M	3/4	156	(1.3)
Plastics From Forest and Field	Chapter M	3/4	159	(1.5)
Flexible Magnets Shed Hardware Image	Chapter M	3/4	167	(-2.2)
Stronger Thermoplastic Elastomers	Dreger	3/25	181	(5.0)
Polyurethane	Hinderaker	2/12	94	(5.0)
Thermoset Elastomers	Theberge & Arkles	2/12	113	(4.0)
Thermoplastic Elastomers	Chapter M	3/4	153	(1.1)
Urethane Foam from a Pressurized Can	Chapter M	3/4	196	(3.8)
	Chapter M	3/4	199	(1.2)
	N/T	10/21	28	(0.8)

### 55, 56. Joining Materials, Other Nonmetals

New Coater and New Coatings Developed for Fasteners	N/T	3/11	6	(0.5)
Coming: 21 Casting Sealing Centers	N/T	3/25	10	(0.7)
Keeping Bolts Tight With Anaerobics	Murray	3/25	135	(5.0)
Double-Plunger Dispenser Cleans Up Epoxy Bonding	Scan	4/8	36	(0.5)
Anaerobic Solves Weld-Porosity Problem	N/T	4/22	6	(0.8)
Sealants	Chapter MD	6/3	280	(2.3)
Engineering Adhesives	Bittence	6/10	92	(5.0)
Structural Adhesive Bonding	Graham	10/7	118	(6.0)
Self-Sealing Fasteners	Chapter FJ	11/18	139	(1.0)
Adhesives	Chapter FJ	11/18	155	(6.0)
Carbon	Chapter M	3/4	212	(1.0)
Why Glass Parts Fail	Matheson	1/22	79	(5.0)
Ceramics	Chapter M	3/4	213	(1.0)
Glass	Chapter M	3/4	215	(1.0)
Improved Ceramic Seals	Guthrie & Luks	3/25	140	(4.0)
'Ma Bell' Tests Lasers 'Talking' into Fibers	N/T	8/12	6	(1.0)
Fibers	Chapter M	3/4	214	(0.8)
Kevlar Looks Good as Parachute Material	N/T	4/8	12	(0.6)
'Ma Bell' Tests Lasers 'Talking' into Fibers	N/T	8/12	6	(1.0)
The Promise of Quick-Quench Materials	Aronson	12/9	20	(4.0)
Muffling Hydraulic Systems	Skaistis & Becker	10/21	124	(5.0)
Fiberboard Houses: for Emergencies? For Underdeveloped Nations?	N/T	1/8	18	(0.7)

### 57. Finishes, Coatings, Lubricants

Reflected Beta Rays Reveal Coating Thickness	Scan	1/22	37	(0.5)
Flying Magnets Coat Complex Parts	Scan	3/11	36	(0.6)
Alloys That Are Only Skin Deep	Dreger	9/23	123	(3.0)
Chrome Deeply Diffused into Mild Steel	N/T	11/11	6	(0.6)
New Coater and New Coatings Developed for Fasteners	N/T	3/11	6	(0.5)
Material Assembled Atomic Layer by Atomic Layer	N/T	10/21	8	(0.7)
Microcapsules Give Early Warning of Fatigue Cracks	Scan	3/8	36	(0.5)
Low-Friction Coating Proves Its Worth in Truck Engine	N/T	2/12	12	(0.7)



Low-Friction Coating Proves Its Worth in Truck Engine	N/T	2/12	12	(0.7)
Coatings That Cut Friction	Seitzinger	10/21	114	(6.0)
Chrome Deeply Diffused into Mild Steel	N/T	11/11	6	(0.6)
Waging War on Rust: Part 2—Resisting Rust	Bittence	11/11	146	(7.0)

## 58. Prefabricated Forms

The Latest in Structural Plastic Panels	Dreger	6/10	105	(3.0)
Plastic Converts Van into Armored Truck	N/T	6/24	6	(0.8)
Material Assembled Atomic Layer by Atomic Layer	N/T	10/21	8	(0.7)
Composite Wing Scheduled for Testing On Twelve Aircraft	N/T	3/11	6	(0.5)
Reinforced Plastic Parts from Low-Pressure Molds	Dreger	1/8	75	(3.0)
Structural Foam	Chapter M	3/4	164	(0.8)
Smooth Finish Molded Into Structural Foam Parts	N/T	3/25	8	(0.7)
Urethane Foam from a Pressurized Can	N/T	10/21	28	(0.8)

# MANUFACTURING PROCESSES

## 61, 62, 63. Metals Casting, Shaping, Forming

Coming: 21 Casting Sealing Centers	N/T	3/25	10	(0.7)
Vacuum Lowers Cost of Investment Castings	Dreger	4/22	62	(4.0)
The Promise of Quick-Quench Materials	Aronson	12/9	20	(4.0)
Hot Isostatic Pressing To Save Air Force Dollars	N/T	5/6	10	(0.8)
Forgings By The Thousands	Dreger	7/8	57	(3.0)
Strong, Low-Cost Forgings From Sprayed-Metal Preforms	Dreger	8/12	86	(2.0)
Hot Isostatic Pressing	Aronson	9/23	118	(5.0)
Extruded Ribs Form Warp-Free Aluminum Panels	Scan	4/8	39	(0.7)
Recipe For Well-Done Staking	Straesser	12/9	154	(2.0)
Pore Profiles Leading to Improved Materials	N/T	2/26	10	(0.7)
7 x Boost in Wear Resistance for Aluminum P/M Parts	N/T	8/12	8	(0.8)
The Promise of Quick-Quench Materials	Aronson	12/9	20	(4.0)
Sheet-Metal Seams	Straesser	9/9	137	(2.0)
Photoelastic Method Evaluates Metal Stampings	N/T	4/8	8	(0.8)
Resonance Reveals Drawability Data	Scan	6/24	48	(1.0)
Formability of Steel Sheets Improved by Temperature Control	N/T	11/11	32	(0.5)
Stampable Plastics Challenge Sheet Steel	Dreger	12/9	134	(6.0)

## 64, 65. Metal Joining, Removal

Plastic Joining	Chapter FJ	11/18	163	(3.0)
Electromagnet Puts Welding Arc in Its Place	Scan	9/9	54	(1.0)
Welding Processes	Chapter FJ	11/18	146	(3.4)
Anaerobic Solves Weld-Porosity Problem	N/T	4/22	6	(0.8)
Ten Tips For Better Weldments	Straesser	4/22	72	(4.0)
HSLA I-Beams Welded Together	N/T	7/22	12	(0.8)
Welded Fasteners	Chapter FM	11/18	24	(3.0)
Electron Beams Tackle Tough Machining Jobs	Drew	2/26	94	(5.0)
Ultrasonic Joining Wins New Jobs	N/T	3/25	34	(0.8)
Brazing Processes	Chapter FJ	11/18	149	(3.1)
Saturated Vapor Solders Complex Parts	Scan	3/25	52	(0.6)
Hot Air Blasts Excess Solder From PC Boards	Scan	5/6	45	(0.5)
Moving Probe Pinpoints Plated Through Hole Quality	Scan	6/24	46	(0.6)

Groovy Iron Aids IC Extraction	Scan	10/21	42	(0.5)
Soldering Processes	Chapter FJ	11/18	152	(2.5)
New Metalworking Processes Tried on Jet-Engine Fairing	N/T	10/7	18	(0.5)
Structural Adhesive Bonding	Graham	10/7	118	(6.0)
Crawler Drill Takes to the Sea	N/T	2/12	10	(1.3)
Machine Tool Checks Up on Itself	Scan	4/22	33	(1.0)
A Jigsaw for Hardened Alloys	Scan	10/21	43	(0.5)
Electron Beams Tackle Tough Machining Jobs	Drew	2/26	94	(5.0)
Machining By Wire	Dreger	9/9	126	(3.0)

## 67, 68. Finishing, Plastics & Rubber Processes

Coming Soon: Low-Cost Product Aluminum Plating	Dreger	3/11	81	(1.1)
Electroplating With a Pen	Scan	8/26	42	(0.5)
Electron Beams Tackle Tough Machining Jobs	Drew	2/26	94	(5.0)
Strong, Low-Cost Forgings From Sprayed-Metal Preforms	Dreger	8/12	86	(2.0)
Flame Spraying To Solve Metal Wear	N/T	12/9	8	(0.5)
Resin Injection Molding	Dreger	5/20	103	(3.0)
Pinpoint Control Refines Rotary Blow Molding	Scan	11/25	44	(1.0)
Twin Screws Speed Up Plastic Extrusion Process	Scan	2/12	44	(0.6)
New Metalworking Processes Tried on Jet-Engine Fairing	N/T	10/7	18	(0.5)
Reinforced Plastic Parts from Low-Pressure Molds	Dreger	1/8	75	(3.0)
Laminated Plastics	Chapter M	3/4	164	(1.9)
Plastic Parts Produced by Spin-Casting	N/T	9/9	10	(0.6)
Woven Fabric Shapes Exotic Bearings	Scan	5/20	46	(1.0)

## 69. General

GMC's General: First 'Finite-Element' Truck	N/T	7/22	4	(1.7)
Automatic Assembly	Chapter FJ	11/18	28	(2.5)

# DESIGN THEORY & TECHNIQUES

## 71, 72, 73. Mechanics, Strength of Materials and Parts

Properties of Plane Cross Sections	Wojciechowski	1/22	105	(1.6)
Calc Program Finds Moments of Inertia	Genneken	10/7	138	(1.0)
Dynamic Distortion in Cam Systems	Tesar & Matthew	3/25	186	(6.0)
Avoiding Vibration in Odd-Shaped Printed-Circuit Boards	Steinberg	5/20	116	(4.0)
The 'Hidden Message' in Mechanical Vibration	Lang	6/10	86	(6.0)
Preventing Vibration Damage in Electronic Assemblies	Steinberg	7/8	74	(4.0)
A Quick, Graphical Way to Analyze Rotor Whirl	Nelson & Glasgow	10/7	124	(7.0)
Listening For The Sounds of Bearing Trouble	Biercheck	11/25	82	(5.0)
Dynamic Distortion in Cam Systems	Tesar & Matthew	3/25	186	(6.0)
Noise Standards Set for Locomotives, Portable Air Compressors	N/T	3/11	8	(0.5)
Taking Accurate Noise-Level Readings	Bentley	6/10	110	(1.0)
Holey Plate Squelches Noisy Pumps	Scan	6/24	44	(0.5)
Coming: Quieter Pumps	Robbins & Logan	9/9	116	(4.0)

Muffling Hydraulic Systems	Skaistis & Becker	10/21	124	(5.0)
Listening For The Sounds of Bearing Trouble	Biercheck	11/25	82	(5.0)
Thick-Wall Cylinders Under External Pressure	Zanker	3/11	80	(1.0)
Why Glass Parts Fail	Matheson	1/22	79	(5.0)
Rating the Load Capacity of Involute Splines	Drago	2/12	104	(6.0)
When ICs Go Bad	Dicken	2/26	78	(4.0)
A New Look at Burst Pressure	Blake	8/22	97	(1.4)
Microcapsules Give Early Warning of Fatigue Cracks	Scan	1/8	36	(0.5)
A Fresh Look At Fatigue	Wirsching & Kempert	5/20	120	(4.0)
Models That Predict Fatigue Failure	Wirsching & Kempert	7/8	65	(5.0)
Fatigue Failure in the Real World	Wirsching & Kempert	8/26	86	(5.0)
Design Codes That Fight Fatigue	Wirsching & Kempert	9/23	108	(6.0)
Designing the Leakproof Gasket	Swick	1/22	100	(4.0)
You Can Predict Creep in Plastic Parts	Rondeau	3/11	67	(5.0)
Thermal Stresses in Cylinders	Ganapathy	1/8	91	(1.3)
Taking a Close Look at Bearing Wear	Dalal	1/8	82	(4.0)
Spring Loading Extends Range of Friction Tester	Scan	3/11	40	(0.6)
Wear Particles Predict Machine Malfunctions	Aronson	8/24	84	(6.0)
Curing Slider Hang-Ups	Kleven	6/24	105	(5.0)

Hydraulic Systems With Precision Reflexes .....	Dransfield & Labrody	5/20	106	(4.0)
Machine Tools Embrace New Technology .....	Article	8/26	70	(8.0)
Renewal Theory—predicting product failure and replacement .....	McCall	3/25	149	(6.0)
Defining 'Precision' In A Control System .....	Sethi	4/8	80	(5.0)
Simple Guide to TP Dimensioning .....	Spotts	1/8	86	(5.0)
Simple Guide to TP Dimensioning .....	Spotts	1/22	84	(5.0)
No Touch Alignment System Works Without Gages .....	Sean	4/8	35	(1.0)
Monte Carlo Simulation for Setting Dimensional Tolerances .....	Corlew & Oakland	5/6	91	(5.0)

## 76. Basic Sciences & Fields

Evidence of New Old Elements Rock				
Physicists .....	N/T	7/22	22	(0.6)
Heat Pictures Tell the Inside Story .....	Aronson	2/12	99	(5.0)
Pipe Lines for Electricity .....	Article	3/25	26	(5.0)
Fireplace Damper Moved Away from the				
Firebox .....	N/T	8/26	18	(0.6)
Computing Temperature Losses .....	Reimann	11/11	153	(1.7)
Gamma Rays Find the Weapon .....	N/T	4/22	10	(1.3)
Radiation-Cured Coatings .....	Lindstrom,			
	Arons &			
	Rafferty	5/6	96	(6.0)
Newly Designed Knee Lets Many Burn Their				
Crutches .....	N/T	4/8	10	(0.7)
Colonizing Free Space .....	Comella	5/6	26	(5.0)
Exerciser Monitors Rider's Heart .....	N/T	10/21	4	(0.6)
Optical Waveguides Carry TV into Homes	N/T	9/9	10	(0.8)
Photoelectric Systems: Industry's Electronic				
Eyes .....	Filichowski	10/7	102	(6.0)
Instant Replay in the Product Development				
Lab .....	Aleks	10/21	120	(4.0)
Screen Cuts Fuel Consumption by 15% .....	N/T	6/10	10	(0.5)
Sailplane and Model Teamed in New Research	N/T	12/9	4	(0.7)

## 77. Experimental Design

Photoelastic Method Evaluates Metal Stampings .....	N/T	4/8	8	(0.8)
Stresses in Circular Plates .....	Tabakman & Lin	7/22	84	(6.0)
Fracture-Mechanics Analysis Checks Out Alaska Pipeline .....	N/T	12/9	10	(0.6)
Stress Analysis of Pressurized Panels .....	Martinelli	12/9	149	(3.0)

Waging War on Rust: Part 1—Understanding Rust	Bittence	10/7	108	(6.0)
Waging War on Rust: Part 2—Resisting Rust	Bittence	11/11	146	(7.0)
Ready-Made Space Suits and Rescue Balls	N/T	5/6	4	(0.7)
Colonizing Free Space	Comella	5/6	26	(0.5)
Shuttle Model Confirms Heating Problem	N/T	6/24	4	(0.4)
U.S. Technology Reaches Mars	Zimmerman	6/24	18	(0.8)
NASA Recruits Space-Shuttle Astronauts	N/T	8/12	10	(0.7)
Enterprise For The Orbital Express	Zimmerman	9/23	20	(0.9)
'Enterprise' Rollout	N/T	10/21	18	(1.4)
Crawler Drill Takes to the Sea	N/T	2/12	10	(1.3)
Sea-Bottom Plow Buries Transoceanic Cable	Cobb	8/12	26	(3.3)
Tool Shop Open to Ocean Depths	N/T	11/25	12	(0.7)
Huge Pressure Vessel To Test Navy's Deep-Diving Gear	N/T	12/9	6	(0.6)
EPA Wants Tougher Evaporative Standard for Autos	N/T	2/26	12	(0.6)
Metals for Nonnuclear War	Schumacher	3/11	57	(3.3)
Electrolysis Separates Oil from Waste Water	N/T	11/11	12	(0.6)

## 81. Engineering Department Operations

Take the Guesswork Out of Project Time Estimates			
NASA Recruits Space-Shuttle Astronauts	Delembro	8/26	66 (4)
Ten Key Factors Affecting Your Job	N/T	8/12	10 (0)
Career Stalled?	Zimmerman	10/21	20 (6)
	Ference, Stoner & Warren		
Engine: Salaries: Where Do We Stand?	3/25	130	(5)
More About Money	Zimmerman	2/26	18 (1)
EMC Gives 5th Report on Technician Salaries	Zimmerman	5/20	33 (0)
Inflation Out-Paces Engineers' Paychecks	Zimmerman	8/12	72 (4)
Personal Communications: The Space Factor	Dalton	9/23	94 (5)
Purchasing: Where Does The Engineer Fit In?	Comella	12/9	120 (5)

## 82, 83. New Product Development, Drafting & Reproduction

Will That New Product Make It?	Lance	2/26	72	(6.0)
Brainstorming Your Way To New Ideas	Ahrens	4/8	66	(3.0)
Taking The Tossup Out Of New-Product Development	Riggio	6/10	82	(4.0)
Instant Replay in the Product Development Lab	Aleks	10/21	120	(4.0)
Geothermal Research Encouraging	N/T	12/9	6	(0.5)
Mastering the Art of Isometric Sketching	Gunther & Chepulis	7/8	78	(2.0)
Elliptical Compass Ends Drafting Drudgery	Scan	7/8	34	(0.7)

## 84. Laboratory & Testing

When ICs Go Bad	Dicken	2/26	78	(4.0)
Composite Wing Scheduled for Testing On Twelve Aircraft	N/T	3/11	6	(0.5)
Souped-Up Tractors Invade Nation's Sports Arenas	Zimmerman	3/11	18	(3.0)
Materials Test System Saves Power	Scan	3/11	38	(0.5)
Spring Loading Extends Range of Friction Tester	Scan	3/11	40	(0.6)
Test Switch Opens Ribbon Cable Lines One At a Time	Scan	3/25	54	(0.5)
Digital Revolution in the Test Lab	Wentz	3/25	144	(5.0)
Shuttle Model Confirms Heating Problem	N/T	6/24	4	(0.8)
Wear Particles Predict Machine Malfunctions	Aronson	6/24	84	(6.0)
Navy Builds an Energy-Test House	N/T	7/22	8	(0.8)
Troubleshooting PC Armatures	Uhis	8/12	96	(1.6)
Logic Circuit Speeds Up Transistor Testing	Scan	8/26	36	(0.7)
Test Equipment For Microcomputers	Raphael & Hou	8/26	78	(4.0)
Current Probe Pinpoints Logic Faults	Scan	9/23	52	(0.6)
Water Tunnel Tests Sub-Launched Missiles, Bids for Wind-Tunnel Jobs	N/T	11/11	4	(1.0)
What's Behind The UL Label?	Plesser	11/25	87	(5.0)
Sailplane and Model Teamed in New Research	N/T	12/9	4	(0.7)

Huge Pressure Vessel To Test Navy's Deep-Diving Gear	N/T	12/9	6	(0.5)
Listening For The Sounds of Bearing Trouble	Beercheck	11/25	82	(5.0)
The 'Hidden Message' In Mechanical Vibration	Lang	6/10	86	(6.0)
Acoustic Emission	Pollock	4/8	72	(5.0)

## 85. Technical Information

'Voluntary' Metric Law Passed in '75	Wise	2/26	24	(2.0)
Which Standards for Metric Retaining Rings?	Millheiser	2/26	86	(4.0)
Noise Standards Set for Locomotives, Portable Air Compressors	N/T	3/11	8	(0.5)
Reducing Metric Conversion Errors	Erisman	6/24	95	(5.0)
Metric Standard Approved by ANSI	N/T	9/23	8	(0.5)
Microcomputer Terminology	Chapter EM&C	4/29	210	(2.0)

## 86, 87. Patents & Patent Law, Personnel & Professional

Patents: Who Needs Them?	Karger	1/22	76	(3.0)
How To Market Your Own Invention	Aronson	5/6	82	(4.0)
Career Stalled?	Ference, Stoner & Warren	3/25	130	(5.0)
What Bugs Engineers?	Imberman	9/9	98	(4.0)
The Over-Motivated Engineer	Steinmetz	10/7	98	(4.0)
Biorhythm: Personal Science or Parlor Game?	Comella	10/21	104	(5.0)
Brainstorming Your Way To New Ideas	Ahrens	4/8	66	(3.0)
Overcoming The Habits That Block Creativity	Marsh	7/8	52	(5.0)
A Short Course in Carpet Climbing	Article	10/7	35	(2.0)
WESCON: It's 25 and Healthy Again	N/T	9/9	36	(3.5)
Cleveland Hosts Triple Engineering Shows And Conferences	Article	10/21	137	(1.0)
Big Unions Make Their Pitch	Zimmerman	2/12	26	(5.0)
Getting the Most From Your Education Dollar	Martinez	4/22	52	(5.0)
Minorities In Engineering: Any Progress?	Fox	11/25	66	(4.0)

# COMPLETE MACHINES

## 911. Ordnance

Upgunning U. S. and NATO Tank Forces	Buchanan	1/8	20	(3.0)
Two To Joust for XM1 Job	N/T	2/26	4	(1.0)
Army Tests Rapid-Fire Mine 'Layer'	Zimmerman	3/25	20	(2.0)
Strain Gages Zero-In Big Gun Quickly	Zimmerman	5/20	36	(2.0)
100+ mph: Ship Sets Speed Record	N/T	8/12	4	(0.6)
Tankers Set Fuzes After Firing Shells	Zimmerman	8/26	10	(2.0)
Coming: The 100-mph Warship	N/T	9/9	4	(0.6)
Mobile Patriot Hardware Rolled Out	N/T	9/23	4	(0.7)
Water Tunnel Tests Sub-Launched Missiles, Bids for Wind-Tunnel Jobs	N/T	11/11	4	(1.0)
Shootout Over The Next Main Battle Tank	Zimmerman	12/9	28	(4.0)

## 912. Machinery

Powered Harrow Saves Time and Energy	N/T	1/22	8	(0.5)
Souped-Up Tractors Invade Nation's Sports Arenas	Zimmerman	3/11	18	(3.0)
Portable Pier Solves Container Unloading Problem	NPT	3/25	32	(0.7)
Mechanizing America's Backyard	N/T	4/8	18	(5.0)
Rotating Flappers Fracture Metal Scale	Scan	8/26	40	(0.5)
Storage Loop Boosts Strip Line Productivity	Scan	8/26	40	(0.5)
Machine Tools Embrace New Technology	Article	8/26	70	(8.0)
NC Inspires New Machine Configurations	Khol	9/23	32	(2.5)
Upgrading Older Machine Tools	Article	10/21	136	(1.0)

## 913. Electrical Machinery

New RPV Impressive on First Flights	N/T	2/12	4	(1.0)
Satellite To Track Car in Around-the-World Auto Race	N/T	4/8	4	(0.8)
U. S. Technology Reaches Mars	Zimmerman	6/24	18	(8.0)
Ambulance Contacts Hospital Via Satellite	N/T	7/8	10	(0.6)
'Ma Bell' Tests Lasers 'Talking' into Fibers	N/T	8/12	6	(1.0)
Sea-Bottom Plow Buries Transoceanic Cable	Cobb	8/12	26	(3.0)
Tankers Set Fuzes After Firing Shells	Zimmerman	8/26	10	(2.0)
Optical Waveguides Carry TV into Homes	N/T	9/9	10	(0.8)
Radar Eye Looks Everywhere Without Moving	N/T	9/23	8	(0.5)
Instant Replay in the Product Development Lab	Aleks	10/21	120	(4.0)

## 914. Transportation

Amtrak Begins To Roll	Aronson	1/22	18	(6.0)
New RPV Impressive on First Flights	N/T	2/12	4	(1.0)
Six-Wheeler May See Grand-Prix Action	Article	2/12	20	(3.0)
Safe Car Built of Clay	N/T	2/26	12	(0.5)
Do-It-Yourself Hovercraft	N/T	3/11	25	(1.0)
Idea Car for Lady Shoppers	N/T	3/25	4	(0.7)
Small Crew Handles Huge Aluminum Sailing Vessel	N/T	3/25	12	(0.7)
Satellite To Track Car in Around-the-World Auto Race	N/T	4/8	4	(0.8)
Great Lakes Super Carriers	Aronson	4/22	18	(5.0)
Indy's George Bignotti	Article	5/6	18	(6.0)
Museum Tackles a 'Transit' Problem	Wise	6/10	18	(4.0)
U. S. Technology Reaches Mars	Zimmerman	6/24	18	(8.0)
New Bus Stresses Comfort and Convenience	N/T	7/8	4	(0.7)
GMC's General: First 'Finite-Element' Truck	N/T	7/22	4	(1.7)
100+ mph: Ship Sets Speed Record	N/T	8/12	4	(0.6)
New Rule Won't Scuttle New Bus Weight Reduction, Fuel Economy Highlight	N/T	8/26	6	(1.0)
Auto Industry's 'Interim' Year	Wise	9/9	18	(11.0)
New Approach to Developing Electric Car	N/T	9/23	10	(0.7)
Countdown For The Orbital Express	Zimmerman	9/23	20	(6.0)
Electronics Paces 1977 Engine Redesign	Wise	10/7	20	(6.0)
'Enterprise' Rollout	N/T	10/21	18	(1.0)
Coming Soon—The VW Diesel	Aronson	11/25	20	(3.0)
Rigging Trains Wheels on All-Terrain Vehicle	Scan	11/25	42	(0.5)
Sailplane and Model Teamed in New Research	N/T	12/9	4	(0.7)

## 916. Fabricated Metal Products

Mechanical Booster Puts the Squeeze on Vise Jaw	Scan	2/26	40	(0.5)
Toothed Ratchet Wrench Takes The Bite Out of Metric Conversion	Scan	3/11	38	(0.5)
Toggles Keep Tabs on Torque	Scan	11/11	44	(0.6)

## 917. Leisure and Hobby

Materials In Sports	Ebert	8/12	18	(5.0)
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# CLASSIFICATION SYSTEM

## 2—FLUID POWER (continued)

The classification system provides nine major (one-digit) classifications, each of which has up to nine (two-digit) sub-classifications. These, in turn, are divided into ten (three-digit) indexing classifications.

Indexing classifications ending in 0 (General) are used to index material concerning several or all indexing classifications ending in 1 through 8. Classifications ending in 9 (Other) are used for material falling within the sub-classification but not within any of the items 1 through 8.

## 1—ELECTRICAL AND ELECTRONIC

- 11 Motors**
  - 110 General
  - 111 Fractional (less than 1 hp)
  - 112 Ac integral horsepower, induction
  - 113 Dc integral horsepower
  - 114 Universal (dc or ac)
  - 115 Multispeed
  - 116 Gearmotor
  - 117 Torque
  - 118 Definite and special purpose, pancake
  - 119 Other: Linear, motor protectors
- 12 Power Supplies**
  - 120 General
  - 121 Batteries, battery chargers, battery holders
  - 122 Dc generators, motor-generators
  - 123 Ac generators, motor-generators, alternators
  - 124 Converters, inverters
  - 125 Transformers, voltage regulators
  - 126 Fuel cells, solar cells, photo cells
  - 127 Thermoelectric supplies
  - 128 Antennas
  - 129 Other
- 13 Switches and Relays**
  - 130 General
  - 131 Mechanical: Pushbutton, toggle, rotary, acceleration
  - 132 Thermally operated: Thermostats, thermistors
  - 133 Pressure operated
  - 134 Limit, snap-action
  - 135 Proximity, photoelectric, magnetic, Hall effect
  - 136 Stepping
  - 137 Relays, circuit breakers
  - 138 Motor starters, motor controls, contactors, starting reactors
  - 139 Other: Reed, mercury-wetted
- 14 Instruments and Controls**
  - 140 General
  - 141 Sensing devices, transducers, thermocouples
  - 142 Solenoids, electric actuators
  - 143 Timers, timing motors, delays
  - 144 Synchros
  - 145 Instrument motors, synchronous
  - 146 Data recorders, readouts, indicators, displays, memories
  - 147 Meters, gages
  - 148 Servo motors, stepping motors
  - 149 Other: Motor silencers
- 15 Circuit Components**
  - 150 General
  - 151 Resistors, varistors, rheostats, potentiometers
  - 152 Capacitors
  - 153 Inductors
  - 154 Solid-state devices: Diodes, transistors, thyristors, SCR's, rectifiers, semiconductor, optical couplers, integrated circuits
  - 155 Tubes, cathode ray tubes
  - 156 Saturable reactors, magnetic amplifiers
  - 157 Fuses, fuse panels, protectors
  - 158 Lasers, masers
  - 159 Other
- 16 Connectors and Wiring**
  - 160 General
  - 161 Rings, brushes, commutators, rotors
  - 162 Terminals, binding posts, terminal boards
  - 163 Contacts, button
  - 164 Plugs, receptacles, connectors, sockets
  - 165 Wiring, cable, cord, harness, bus bars, coaxial, circuits, grounding
  - 166 Anted circuits, stitched circuits
  - 167 Superconductors
  - 168
  - 169 Other: Lenses, mirrors, reticles, reflectors, prisms, photosensors
- 17 Miscellaneous Components**
  - 170 General
  - 171 Magnets, electromagnets
  - 172 Chassis, control panels, keyboards
  - 173 Insulation, encapsulation, shielding, jacketing, conduit
  - 174 Cooling elements
  - 175 Lamps, lighting elements, fiber optics, strobes
  - 176 Heaters, heating elements, ovens
  - 177 Electric clutches, electric brakes
  - 178 Ignition systems
  - 179 Other
- 19 Systems & Assemblies**
  - 190 General
  - 191 Amplifiers, preamps
  - 192 Control systems: Regulators, numerical control, digital controllers
  - 193 Electronic computers, calculators, peripheral equipment
  - 194 Microprocessors
  - 195 Adjustable-speed drives
  - 196 Servomechanisms
  - 197
  - 198 Packaging (electrical/electronic)
  - 199 Other

## 2—FLUID POWER

- 21 Fluids**
  - 210 General
  - 211 Hydraulic fluids
  - 212 Coolants, refrigerants
  - 213 Cleaners, solvents (see 577)
  - 214 Lubricants (see 576)
  - 215
  - 216
  - 217
  - 218 Aerosols, pressurized liquids
  - 219 Other
- 22 Fluid Conditioners**
  - 220 General
  - 221 Fluid storage, pressure vessels, reservoirs
  - 222 Filters, strainers, screens, baffles
  - 223 Renovators (Note, 223 = 222 + 286 + 296)
  - 224 Heat exchangers
  - 225 Coolers, radiators, heat pipes
  - 226 Heaters, burners
  - 227 Driers, evaporators
  - 228 Humidifiers, mixers, carburetors
  - 229 Other
- 23 Fluid Conductors**
  - 230 General
  - 231 Tubing (pressure) (see 587)
  - 232 Hose, ducts, bellows
  - 233 Pipe
  - 234 Fittings
- 235 Joints, couplings, unions, flanges, adapters
- 236 Mufflers
- 237 Hydrofoils
- 238
- 239 Other: Applicators, dispensers, reversers
- 24 Linear Devices**
  - 240 General
  - 241 Cylinders, pistons, cylinder mounts
  - 242 Accumulators
  - 243 Intensifiers, boosters, rams
  - 244 Actuators, bellows, diaphragms
  - 245 Pumps
  - 246 Motors
  - 247
  - 248 Compensators
  - 249 Other: Impellers, air guns
- 25 Rotary Devices**
  - 250 General
  - 251 Pumps, rotary, centrifugal
  - 252 Fluid motors, brakes, high-torque low-speed
  - 253 Air motors
  - 254 Compressors
  - 255 Rotary actuators
  - 256 Winches
  - 257 Propellers (see 357)
  - 258 Centrifuges
  - 259 Other

- 26 Seals**
  - 260 General
  - 261 Material seals (O-ring)
  - 262 Mechanical seals
  - 263 Gaskets
  - 264 Wiper rings, piston rings
  - 265 Packings
  - 266 Labyrinth
  - 267
  - 268 Bellows, protective covers
  - 269 Other: Diaphragms, rolling diaphragms, closures, plugs
- 27 Valves**
  - 270 General
  - 271 Directional control
  - 272 Flow control, faucets, flow dividers
  - 273 Pressure control, relief vacuum breakers
  - 274 Servo valves
  - 275 Valve blocks, manifolds
  - 276 Nozzles, venturies, orifices, poppets
  - 277 Proportional flow or pressure
  - 278
  - 279 Other

## 3—MECHANICAL

- 31 Power Sources**
  - 310 General, energy
  - 311 Jet engines
  - 312 Internal combustion engines
  - 313 Turbines, turbofans, turbojets
  - 314 Atomic, nuclear power
  - 315 Exotic fuel engines, rockets
  - 316 Fuels, propellants, explosives, coal, natural gas, hydrogen, fuel oil
  - 317 Steam
  - 318 Geothermal, wind, water, solar, tidal
  - 319 Other
- 32 Constant-Speed Drives & Transmissions**
  - 320 General: Speed reducers
  - 321 Chain
  - 322 Belt
  - 323 Friction: Ball, disc, wheel, cone
  - 324 Gear
  - 325
  - 326
  - 327
  - 328
  - 329 Other: Reversing
- 33 Adjustable-Speed Drives & Transmissions**
  - 330 General: Speed reducers
  - 331 Chain
  - 332 Belt
  - 333 Friction: Ball, disc, wheel, cone
  - 334 Gear
  - 335
  - 336
  - 337
  - 338
  - 339 Other: Reversing
- 34 Drive Components**
  - 340 General
  - 341 Transmission chain, cable, cable fittings, cable splices, shackles
  - 342 Belts, belfing
  - 343 Gears, gearing, racks, pinions
  - 344 Sprockets
  - 345 Pulleys, sheaves, idlers, tensioners
  - 346 Conveyor chain, conveyor belts
  - 347 Conveyor screws, roller conveyors
- 348 Other
- 35 Rotational Components**
  - 350 General
  - 351 Antifriction bearings: Ball, roller, needle, linear, thrust, pillow blocks
  - 352 Sleeve bearings: Gas, solid-lubricant, bushings, rod ends, ball joints
  - 353 Flexible couplings, universal joints, flexible shafts
  - 354 Torque converters, fluid couplings
  - 355 Shafts, axles, splines, crankshafts, spindles
  - 356 Clutches, brakes, power absorbers, torque limiters
  - 357 Fans, blowers, propellers (see 257)
  - 358 Reels, winches, hoists
  - 359 Other: Flywheels
- 36 Mechanisms**
  - 360 General
  - 361 Cams, cam followers
  - 362 Linkages, cranks
  - 363 Intermittent-motion, periodic-motion, indexing, gyrotory-motion, mechanical escapements, ratchets
  - 364 Three-dimensional
  - 365 Motion converters, leadscrews, jacks, actuators
  - 366 Spring motors
  - 367 Telescoping members, collapsing members
  - 368 Manipulators, vibrators, robots, separators
  - 369 Other
- 37 Controls**
  - 370 General
  - 371 Push-pull
  - 372 Transducers (to mechanical)
  - 373 Gyros, gyroscopes
  - 374 Mechanical counters
  - 375 Safety devices, audible warning devices
  - 376
  - 377
  - 378
  - 379 Other
- 39 Systems**
  - 390 General

## 4—ASSEMBLY COMPONENTS

- 41 Fasteners**
  - 410 General
  - 411 Inserts
  - 412 Nuts, locknuts
  - 413 Pins, dowels, staples
  - 414 Quick operating panel-type, latches
  - 415 Retaining rings, keys, collars, frictional shaft connectors, shaft-hub connectors, tolerance rings
  - 416 Rivets, blind rivets
  - 417 Screws, bolts, studs, shear bolts
  - 418 Washers, grommets, eyelets, spacers, bushings, stand-offs
  - 419 Other: Spring clips, clamps, zippers, wire ties, belt splicing, captive panel hardware, captive fasteners
- 42 Springs and Isolation Devices**
  - 420 General
  - 421 Fluid & air springs
  - 422 Helical wire springs
  - 423 Leaf springs, cantilever
  - 424 Vibration isolators, mounts
  - 425 Hydraulic-damping devices, shock absorbers, snubbers
- 426 Mechanical damping devices
- 427 Spring-loaded devices
- 428
- 429 Other: Belleville, constant force
- 43 Miscellaneous**
  - 430 General
  - 431 Locks
  - 432 Nameplates, labels, wire markers, signs
  - 433 Dials, knobs, handles, drawer pulls
  - 434 Shims
  - 435 Enclosures, housings, cabinets, cases
  - 436 Wheels, tires, rollers, casters, ball transfers, rings
  - 437 Slides, ways
  - 438 Hinges, brackets
  - 439 Other: Razor blades, brushes, bells, knives, buzzers, chimes, bases, boots, bellows, way protectors
- 44 Mechanical Measurement Equipment**
  - 440 General
  - 441 Inspection tools and fixtures
  - 442 Gage blocks, micrometer heads
  - 443 Meters, gages



## 5—MATERIALS

### 51 Ferrous Metals

- 510 General
- 511 Cast iron, malleable iron, cast carbon, alloy steels
- 512 Wrought carbon, alloy steels
- 513 Free-machining steels
- 514 Stainless steels, high alloys, high temperature steels
- 515 Specialty steels (tool, die, electrical)
- 516
- 517 High-strength low-alloys
- 518 Magnetic alloys
- 519 Other

### 52 Nonferrous Metals

- 520 General
- 521 Aluminum
- 522 Copper, brass, bronze, beryllium copper
- 523 Magnesium
- 524 Nickel
- 525 Titanium
- 526 Zinc
- 527 Refractory metals: Tungsten, tantalum, molybdenum, columbium
- 528 Precious metals
- 529 Other: Tin, lead, chromium, vanadium

### 53 Plastics

- 530 General
- 531 Thermoplastic plastics (nylon, Teflon)
- 532 Thermosetting plastics (epoxy, phenolic, filled silicones, rigid urethanes)
- 533 Laminated plastics, vulcanized fiber
- 534 Reinforced, filled plastics
- 535 Porous plastics
- 536 Colors for plastics
- 537 Plastic trims
- 538
- 539 Other: Degradable

### 54 Rubber and Elastomer

- 540 General
- 541 Natural rubber
- 542 Synthetic rubber
- 543 Elastomeric plastics: Flexible silicones and urethanes
- 544 Hard rubber
- 545
- 546
- 547
- 548
- 549 Other

### 55 Joining Materials

- 550 General

- 551 Adhesives, sealants, encapsulants, caulking, grout
- 552 Welding rods
- 553 Brazing, soldering alloys
- 554
- 555
- 556
- 557
- 558
- 559 Other

### 56 Other Nonmetals

- 560 General
- 561 Carbon, graphite, diamonds
- 562 Glass, ceramics, quartz
- 563 Refractory materials, mica
- 564 Carbides, cermets
- 565 Mineral and synthetic fibers, felt, fabrics
- 566 Insulating materials (thermal, sound)
- 567 Wood, cork, composition board, paper
- 568 Chemicals, phosphors, inks
- 569 Other: Abrasives, friction materials, synthetic crystals, heat-sensitive liquid crystals

### 57 Finishes, Coatings & Lubricants

- 570 General
- 571 Metallic coatings
- 572 Chemical coatings, electrochemical coatings, photosensitive
- 573 Organic finishes: Lacquers, synthetic enamels, paints, varnishes
- 574 Porcelain enamels, vitreous coatings
- 575 Plastic coatings, plastic powders
- 576 Lubricating materials (see 214)
- 577 Cleaners, solvents (see 213)
- 578 Mechanical surface finishes
- 579 Other: Corrosion inhibitors

### 58 Prefabricated Forms

- 580 General
- 581 Film, tape, sheet, foil, plate
- 582 Wire, wire cloth, knitted wire mesh, wire rope, cable
- 583 Patterned, perforated, expanded metals, textured, prefinished
- 584 Laminates
- 585 Composite materials
- 586 Structures: Honeycomb, foam, sandwich, isogrids, geodesic
- 587 Structural shapes: Tubing, channels
- 588 Balls, beads
- 589 Other

## 7—DESIGN THEORY & TECHNIQUES

### 71 Mechanics

- 710 General
- 711 Statics (at rest)
- 712 Dynamics (force to create motion)
- 713 Kinematics (motion in abstract)
- 714 Vibration, natural frequency
- 715 Shock
- 716 Noise, sound, music
- 717 Viscosity
- 718 Strain and stress
- 719 Other

### 72 Strength of Material

- 720 General
- 721 Elastic theory
- 722 Plastic theory
- 723 Fatigue, endurance
- 724 Creep
- 725 Impact stress
- 726 Thermal stress
- 727 Friction, wear
- 728 Fracture
- 729 Other: Hardness

### 73 Strength of Parts

- 730 General
- 731 Tension, compression
- 732 Bending
- 733 Shear, torsion
- 734 Surface contact stress
- 735 Plates
- 736 Cylinders, columns
- 737 Rotating discs, rotors
- 738 Critical speed, critical flow
- 739 Other

### 74 Human-Factors Engineering

- 740 General
- 741 Styling
- 742 Color
- 743 Safety, comfort, protective clothing
- 744 Illumination
- 745 Human limitations
- 746 Spare/replacement parts
- 747
- 748
- 749 Other: Tactile graphics

### 75 Design Analysis & Synthesis

- 750 General

- 751 Mathematical methods, statistics
- 752 Graphical techniques
- 753 Analogs, models, simulators
- 754 Computer techniques
- 755 Reliability, quality control
- 756 Dimensioning, tolerances
- 757 Maintenance
- 758 Value analysis
- 759 Other

### 76 Basic Sciences & Fields

- 760 General
- 761 Physics
- 762 Chemistry
- 763 Thermal, thermodynamics, cryogenics, heat transfer, combustion
- 764 Radiation
- 765 Biosciences
- 766 Optics, photography, holography, photoelasticity
- 767 Ultrasonics
- 768 Aerodynamics
- 769 Other: Economics, metrology

### 77 Experimental Design

- 770 General
- 771 Prototypes, breadboards
- 772 Testing, stress analysis
- 773
- 774
- 775
- 776
- 777
- 778
- 779 Other

### 78 Environmental Design

- 780 General
- 781 Corrosion, rust
- 782 Mold, fungus
- 783 Outer space
- 784 Under sea
- 785 Pollution
- 786 Waste treatment, reclamation, salvage, restoration, conservation, recycling
- 787
- 788 High temperature, low temperature
- 789 Other

## 6—MANUFACTURING PROCESSES

### 61 Metal Casting

- 610 General
- 611 Sand
- 612 Shell mold
- 613 Permanent mold, gravity, low-pressure
- 614 Centrifugal
- 615 Investment
- 616 Die
- 617 Plaster mold
- 618 Continuous
- 619 Other

### 62 Metal Shaping

- 620 General
- 621 Forging, cold forging
- 622 Extrusion, impact extrusion
- 623 Heading, upsetting, cold forming
- 624 Thread, form rolling
- 625 Powder metallurgy, porous metals, fiber metals

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628 Hot isostatic pressing

629 Other

### 63 Metal Forming

- 630 General
- 631 Sheet forming, plate forming
- 632 Stamping, drawing, blanking, embossing, coining
- 633 High-velocity forming, explosive forming
- 634 Spinning
- 635 Roll forming
- 636 Tube forming
- 637 Wire forming
- 638 Stretch and compression forming
- 639 Other: Magnetic forming

### 64 Metal Joining

- 640 General
- 641 Arc welding
- 642 Gas welding
- 643 Resistance welding
- 644 High-energy welding: Plasma, electron beam, explosive bonding, ultrasonic, magnetic, solid state
- 645 Flame cutting
- 646 Brazing
- 647 Soldering, desoldering
- 648 Adhesive joining, bonding
- 649 Other: Interlocking, keylock, dove-tail, sewing, bolted joints, riveting

### 65 Metal Removal

- 650 General
- 651 Planing, broaching
- 652 Lathe turning, screw machining
- 653 Milling, hobbing, gear shaping, sawing

- 654 Drilling, boring, tapping
- 655 Grinding, abrasive machining
- 656 Honing, lapping, polishing, burnishing
- 657 High-energy machining: Spark, laser, water jet
- 658
- 659 Other

### 66 Metal Treating

- 660 General
- 661 Heat treating
- 662 Surface treating: Carburizing, nitriding
- 663 Shot peening, surface working
- 664 Chemical milling, etching, photochemical machining

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669 Other

### 67 Finishing

- 670 General
- 671 Chemical, solvent cleaning
- 672 Mechanical finishing, tumbling
- 673 Conversion coating, anodizing, electroplating
- 674 Electroplating, vacuum metallizing
- 675 Metal spraying, flame spraying, hard facing, plasma spray, plasma arc, electrostatic
- 676 Painting
- 677 Hot stamping: Branding
- 678
- 679 Other

### 68 Plastics & Rubber Processes

- 680 General
- 681 Molding, injection molding, forging, rotational molding
- 682 Extrusion, pultrusion
- 683 Sheet forming
- 684 Laminating
- 685 Casting
- 686 Stamping, machining, fabricating, forming, forging
- 687 Calendaring, coating, plating
- 688 Encapsulating
- 689 Other: Filament winding, welding

### 69 Miscellaneous

- 690 General
- 691 Assembly, automatic assembly, micro-assembly
- 692 Packaging, storage, shipping
- 693 Balancing rotating machines

## 8—ENGINEERING MANAGEMENT & OPERATION

### 81 Engineering Department Operations

- 810 General
- 811 Structure, organization
- 812 Costs, budgets
- 813 Programming, planning
- 814 Personnel policies
- 815 Recruiting, evaluation, training
- 816 Managerial talent
- 817 Compensation, pensions
- 818 Communication
- 819 Other

### 82 New Product Development

- 820 General

### 83 Drafting & Reproduction

- 830 General
- 831 Management, control systems
- 832 Drafting practices, techniques
- 833 Technical illustration
- 834 Drafting equipment
- 835 Reproduction equipment, systems
- 836 Furniture, drawing files
- 837
- 838
- 839 Other

### 84 Laboratory & Testing

- 840 General
- 841 Nondestructive testing
- 842 Dynamic analysis

### 85 Technical Information

- 850 General
- 851 Engineering libraries, files, books, museums

- 852 Information classification, retrieval
- 853 Specifications, standards, metrication
- 854 Report writing, articles, papers, oral
- 855 Part numbering, part names (nomenclature)
- 856 Engineering records
- 857
- 858 Security, protection
- 859 Other

### 86 Patents & Patent Law

- 860 General

### 87 Personal & Professional

- 870 General
- 871 Creativity, inventiveness
- 872 Meetings, shows
- 873 Contests, awards
- 874 Societies
- 875 Professional licensing, certification
- 876 Unions
- 877 Education, curriculums, seminars, career planning
- 878 Product litigation, expert witness
- 879 Other: Women

### 88 Outside Services

- 880 General
- 881 Engineering design services
- 882 Industrial design services
- 883 Consulting to government

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889 Other

## 9—MISCELLANEOUS

### 91 Complete Machines

- 910 General
- 911 Ordnance: Tanks, missiles, rockets, ammunition (SIC 19)
- 912 Machinery: Agricultural, construction, machine tools, office machines, materials handling (SIC 35)
- 913 Electrical machinery: Communication, radio, radar, TV, appliances, X-ray (SIC 36)
- 914 Transportation: Automotive, aircraft, ships, railroad, spacecraft, undersea craft (SIC 37)

- 915 Instruments: Medical, dental, photographic, watches (SIC 38)

- 916 Fabricated metal products: Hand tools (SIC 34)
- 917 Toys, playground equipment, sports equipment, recreational equipment

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919 Other

### 99 Unclassified

- 990 General



